Respondent: Citytram, LLC. stephen@citytram.org 954-801-7880

First, my compliments to the city of San Jose for the RFI it authored. It is well written, clear, and to the point, "transit must improve to be competitive with auto modes to enable car free living for more people in the area".

Unfortunately and not surprisingly, the RFI is rich in evidence of self defeating thinking. Questions of "corridors" and "frequencies" suggest a bias that "public transit" == "mass transit". Line haul solutions are a proven failure. They are too slow to attract car users, less convenient for car users, and too expensive to be economically viable without car users. We need to be thinking in terms of "covering neighborhoods" more than "connecting activity centers". And services need to be on-demand in order to match the immediacy of car use, rather than "frequent" in order to lessen the inconvenience of waiting. If you abandon your producer perspective, and instead adopt a consumer perspective, "public transit" == "personal transit".

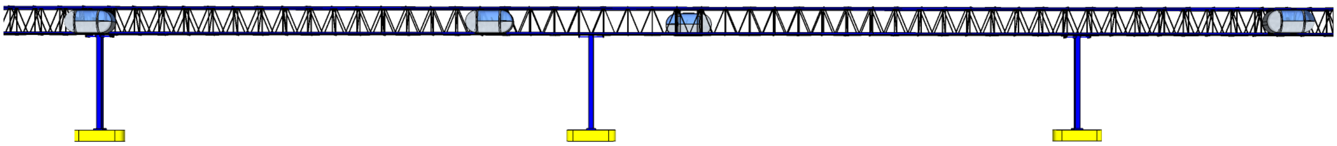
The architecture that will work (attract car users) will be gridded/networked, hierarchical, and on-demand (just like our auto systems are today). So this RFI response is an attempt to take this broader overall view, extract a piece from it, and format it in the manner you have requested.

A. Respondent Profile

i. Citytram, LLC
ii. 961 SW 176 Ave Pembroke Pines, FL. 33029
iii. Citytram is a newly formed sole proprietorship LLC. (registration effective Jan 2020 for tax purposes)
iv. Stephen Hamilton, founder and CEO
v. stephen@citytram.org
vi. 954-801-7880 (cell) 954-436-1040 (office)
vii. Citytram is a real estate development company specializing in public transit infrastructure. It partners with public agencies to develop the rights-of-way they own, producing hard infrastructure assets and profit making special purpose entities to operate and maintain those assets. Citytram benefits from equity in and income from those special purpose entities.
viii. Public transit is organizationally broken, and must be fixed from the outside – commercial interests. Public transit is a large existing market that is ripe for re-segmenting with a new technology. For the technology to be both optimal (for our purpose) and familiar (for low risk replication), Citytram will own (proprietary) the technology it deploys. Like any successful technology based startup, the plan is to define a small enough minimum viable product (MVP), secure venture funding to develop it, and find the right first customer/partner. Input from that partner is critical to define the correct MVP. Commitment of that partner is key in securing the venture capital. Patience of that partner is essential, to absorb the uncertainties in development schedules.

    Currently PRT technology is the only viably profitable technology for broad use. The founder Stephen Hamilton spent 2 years creating the concept and performing design investigations to prove the concept (low cost PRT) is feasible, and affordable, and optimizing the design choices. He then spent 2 years advocating for transit agencies in Florida (Dade, Broward, Pinellas counties) to study and deploy PRT using existing providers. An open RFQ in Dade county for which no current suppliers would bid was the motivation to form the company (Aug 2019) to accelerate development of the proprietary technology. The objective is to build a viable US PRT supplier and a boot a vibrant US market. Seed funding is available. Team assembly is in high gear now.

B. Proposed Concept



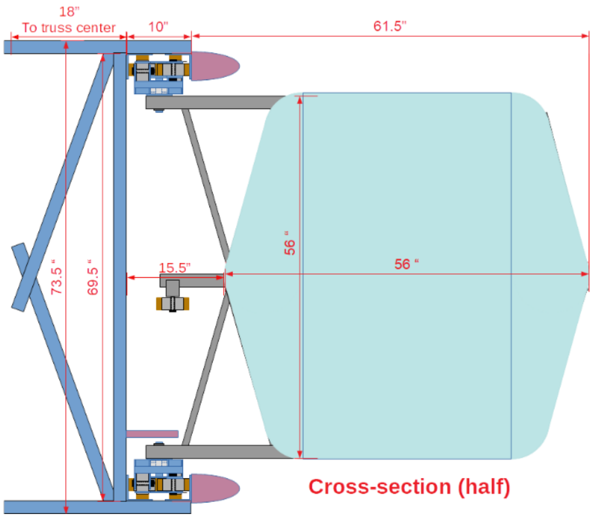
Citytram provides an automated taxi service. That is it provides on-demand, non-stop point-to-point trips exclusively (no required sharing with strangers) to small self-selected groups of 1 to 3 riders. The service is provided by an elevated captive bogie style Personal Rapid Transit technology which was specifically and carefully designed to minimize infrastructure deployment costs. The technology is electrically driven, automated, and extremely safe. Thus it is a low emissions solution, and an energy efficient solution, as well as being economically efficient. It can be operated at a profit, including covering debt service on the capital to build it, while still providing riders a reliable transit solution that is cheaper than private car ownership. Its on-demand and non-stop nature will provide transit times that rival or best those experienced by private car users. So this technology offers the best chance for public transit to make a serious reduction in local car use.

A network of elevated guideways along major arterial roads is used to cover large sub-urban areas spanning multiple neighborhoods/municipalities. Vehicles are locked to those guideways in roller-coaster like fashion so they can be light weight (minimal expense) yet safe. Off-line stations are placed approximately every ½ mile to provide reasonable pedestrian access in addition to fast on-demand transfer to a pick-up/drop-off service. For stations in residential (less dense) neighborhood, individual semi-automated mobility scooters and existing sidewalks and bicycle lanes are used for that low speed shuttle to the area around the stations. Riders can use an on-line app to reserved door-to-door on-demand travel. The semi-autonomous scooter will self-drive to the pickup address. The rider drives the geo-fenced scooter to the PRT station for rapid transfer to PRT. The process is reversed on the destination end of the trip.

C. Physical Elements

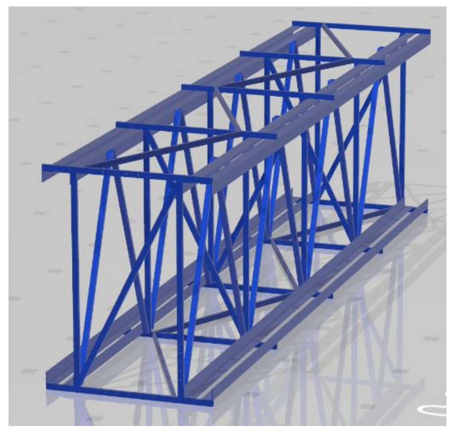
Guideways / Conveyors

The guideway is an extremely long 4 foot wide by 6 foot tall steel box truss. The truss is elevated sufficiently to span over crossing streets and traffic lights with sufficient clearance to avoid obstructing traffic and views (usually 24 ft). Pedestal, cantilevered, and cross road bridging steel towers are used to provide that elevation (as demanded by the alignment). The steel is coated for corrosion resistance, and can be painted the color selected by the operating agency. Drilled shafts are used for the tower foundations. The shafts extend 30 inches above ground, and are surrounded by crash protection barrels for protection, creating a 5 foot by 15 ft footprint (roughly 1 parking space). It is expected that the row of foundations would be placed along the curb in an on-street parking lane; or in a strip between curb and sidewalk; or in a median; or along the edge of a wide sidewalk.

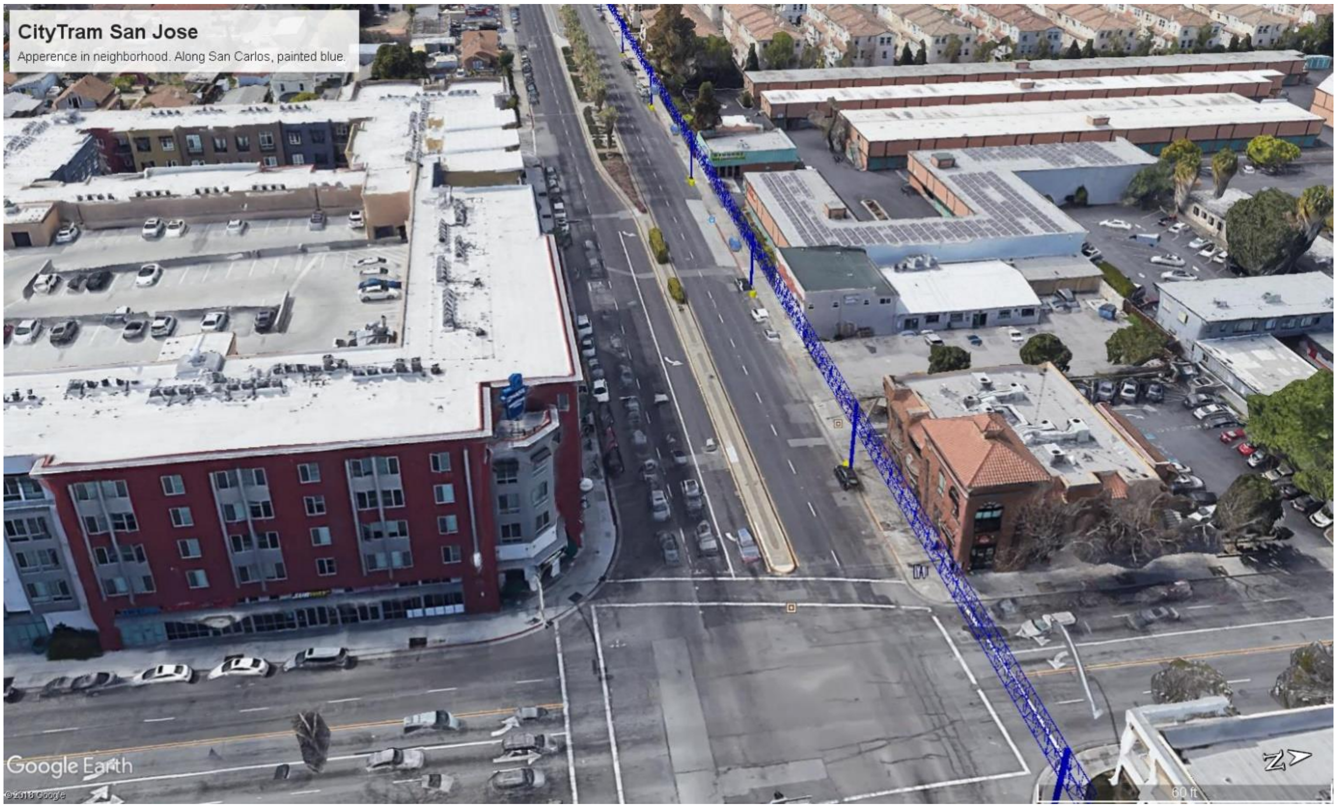


Cross-section (half)

Vehicles (called pods) are cantilevered off the sides of the box truss, extending 72 inches beyond the guideway truss to the side. So 1-way guideway requires a 120 inch (12 ft) wide right-of-way; and 2-way guideway requires a 180 inch (15 ft) wide right-of-way. The 72 inch depth of the truss sections give them the vertical rigidity to span long distances. Typical span is 110 ft. The 36 inch width of the sections give them the horizontal rigidity to resist crosswind forces and cornering forces. The same section (56 inches wide overall) is used for 1-way guideway and for 2-way guideway.



The guideway is constructed of 44-foot sections linked end-to-end with bolts. The section looks like an open web steel joist (commonly used to support floor and roofs in buildings) that was split vertically, and pulled apart into a 36-inch wide by 72 inch tall box truss. The truss panels are 66 inches (5.5 ft) long. The top and bottom surfaces of the box truss are Warren trusses, with the cross members extending 10 inches beyond the box so that rails can be mounted to them. The rails are 4 x 4 x 1/4 inch angle bar. On each side of the box truss a pair of opposing angles creates a U channel on the bottom of the box, and another pair of opposing angles creates an inverted U channel on the top of the box. The bogie positions wheel trucks fitting into these U channels at the top and bottom rails, and the pod is cantilevered off the bogie to the side.


CityTram San Jose
Apperence in neighborhood. Along San Carlos, painted blue.
Google Earth


CityTram San Jose
Apperence in neighborhood. Along San Carlos, painted blue.
We Sell Boxes
Google Earth
©2018 Google
Image Landsat / Copernicus
Legend
5.98 ft

The guideway distributes a single phase of AC power, which is used to power the pods in transit. As shown in the cross-section figure above, the rails are adorned with small airfoils. These serve to minimize crosswind forces on the structure. The structure is designed for survival in 190 mph crosswinds. The airfoils also serves other functions. It includes a private communications network between pods and the central control system. Finally, piping is included to pump hot water in extreme cold weather, to extend the operating environment.

Stations

While each site alignment is unique, it is generally expected that Citytram PRT systems will include approximately 1 station for every one half mile of guideway. This puts system access within a ¼ mile walk all along the guideway. All stations are off-line, so that pods entering or leaving the station do not impede progress along the main line. The off-line guideway connecting to the station operates as an arrival queue and a departure queue to buffer station boarding and un-boarding rates from main line capacity. Off-line acceleration and braking lanes connect these queues to high speed switches along the main line. Where stations connect to bi-directional guideways they may be connected to only one direction (directionally specific station pairs), or they may serve access in both directions (including directional mergers and splitters on entry and exit to the station, respectively). In the latter case (which should be lower cost and more common), the entry and exit paths for one direction will include over/under passes of the main line to get to the station.

There are various station configurations for differing needs. Generally the configurations represent different combinations of a set of basic floorplan building blocks. The intent is to enable accelerated and/or pre-fab manufacturing of these components to lower construction costs. The architecture of these station components also intends to limit, as much as is possible, pedestrian access to just the ground floor. The intent of this also is minimizing station cost. The pedestrian access areas of a station are enclosed and environmentally controlled.

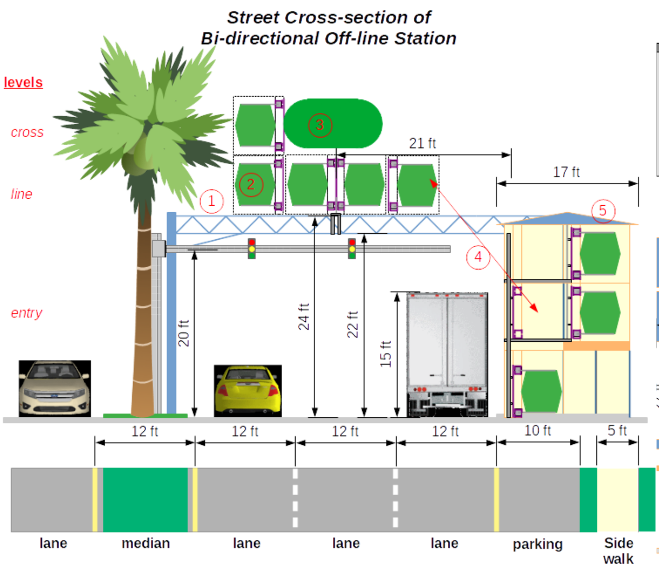
A lobby area is one of the building blocks. The lobby is where riders enter and leave a station, where they engage in ticketing or check-in, and where they occasionally may be asked to wait a short period for a vehicle to be made available for boarding. Configurations often include 2 lobbies – one on each end of the station – to balance demand and shorten customer walks.

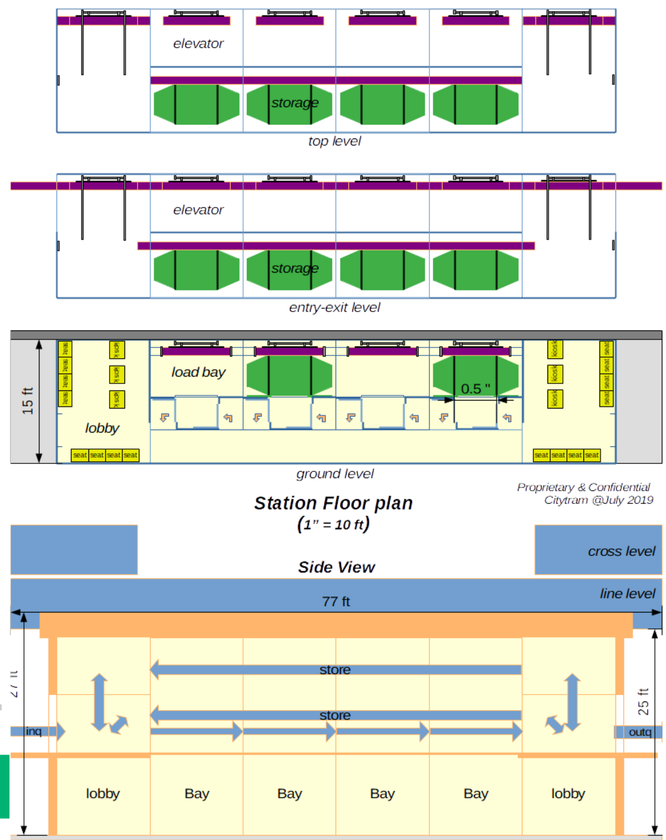
Loading bays, which are provided in pairs, is another building block. The system uses parallel boarding (rather than serial boarding). This prevents one slow travelling group from blocking station boarding/alighting progress. The loading bays are numbered (like gates at an airport) so that a riding group can be directed to the vehicle they will exclusively use for their trip. The number of loading bays will determine the maximum rate at which pods can arrive and depart. So the number of loading bay pairs will vary from station to station depending upon the performance needs predicted for that station.

Stations also provide for some protected storage of empty pods. This storage allows loading bays to be made clear for soon to arrive laden pods without clogging up the main line with empty pods. It also provides a local cache of empty pods for quick access when a burst of departures occurs, so that departing groups do not have to wait long for an empty pod to arrive in their departure loading bay.

pod storage	station length (ft)	loading bays (n)	th (sec)	tcycle (sec)	tpod (sec)	pod occupancy Rpod (pods/hr)	1.2 typ boards (pphpd)	3 max boards (pphpd)
5	66	**2**	4.92	38.40	19.20	187	225	562
10	88	**4**	8.92	42.40	10.60	340	408	1019
15	110	**6**	12.92	46.40	7.73	465	559	1396
20	132	**8**	16.92	50.40	6.30	571	686	1714
25	154	**10**	20.92	54.40	5.44	662	794	1985
30	176	**12**	24.92	58.40	4.87	740	888	2219
35	198	**14**	28.92	62.40	4.46	808	969	2423
40	220	**16**	32.92	66.40	4.15	867	1041	2602
45	242	**18**	36.92	70.40	3.91	920	1105	2761
50	264	**20**	40.92	74.40	3.72	968	1161	2903
55	286	**22**	44.92	78.40	3.56	1010	1212	3031
60	308	**24**	48.92	82.40	3.43	1049	1258	3146

It is expected that some local property owners along an alignment will see the value in having a station directly on their property, and negotiate to provide funding and/or use of a portion of their land (retail parking lots for example). But this will not the case everywhere. So the two station configurations described here are for the most extreme and difficult cases, where the stations must be restricted to the existing public rights of way.

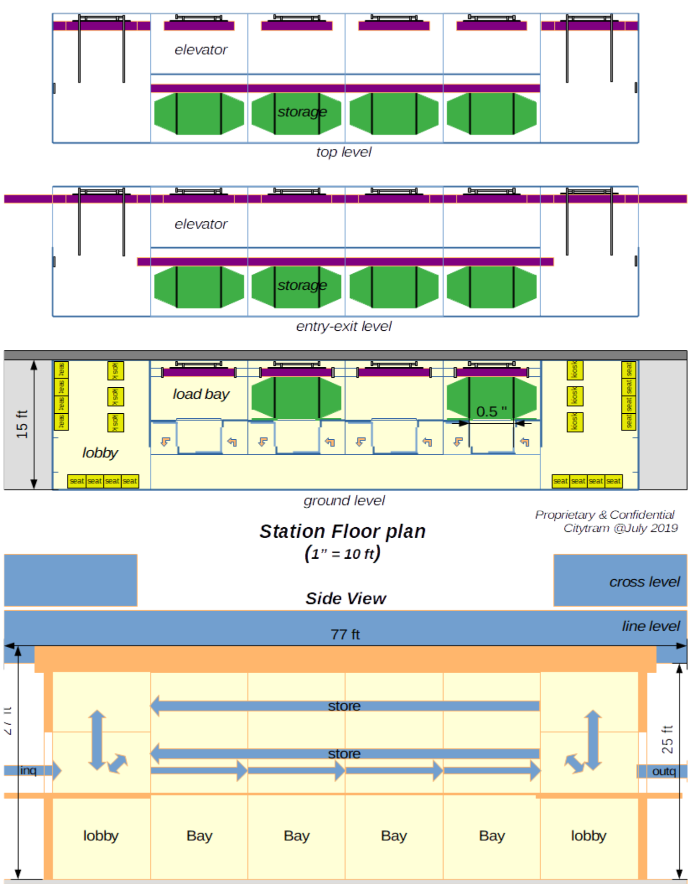


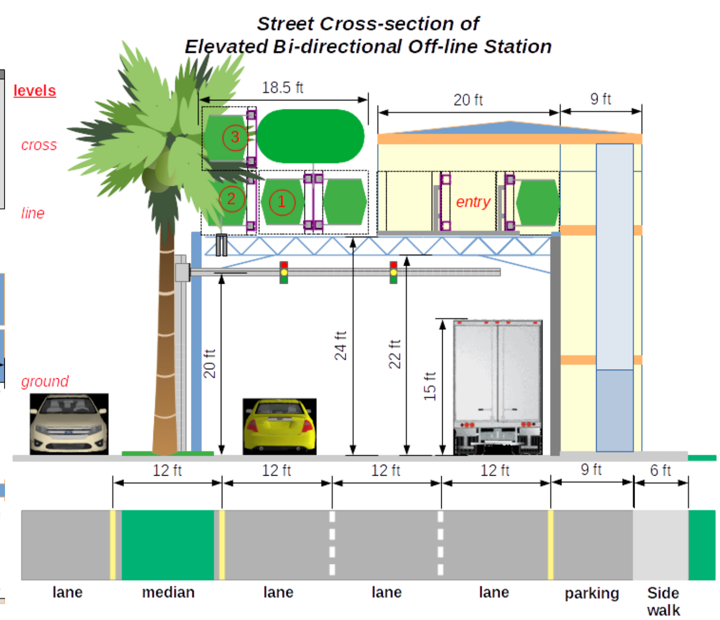


The first configuration provides a 4 bay station with local storage for 10 pods. It is a 3 level building that is 27 feet tall. The ground floor has normal 10 foot ceiling heights. The 2 storage levels above are 7 feet each. He building has a very narrow ground aspect, at 17 feet wide and 77 feet long (approximate length of 2 city buses end-to-end). The width allows it to be placed in the cross section space commonly allocated for an on-street parking lane, a short grass edge strip, and the adjacent sidewalk. In some locations a wide center median is available and sufficient to host such a building. On the ground level, an outdoor roof-protected porch is on either end, leading to the entrance and exit doors to lobby areas. Loading bays are arranged linearly in between. Bay pairs require 22 feet of length. So this same basic configuration can be used for 2, 4, 6, 8, 10, or 12 bay stations.

The loading bays are actually the ground floor for special elevators. Riders enter and exit the pods at that level. The pods themselves act as the elevator cars. The elevators have two carriages – one above the other – which act as short guideway segments. So when a pod is in the down position on an elevator, the carriage above allows other pods to cross above it horizontally. This permits all bays to be accessed in parallel for both entrance and exit.

There will be cases where the street cross-section is even more constrained. This second configuration exists for those cases. The ground width is only 10 ft, so that it can reside in an on-street parking lane and only encroach past the curb by 1 ft (into sidewalk). This station configuration uses normal commercial elevators (one per bay) to lift riding groups up to the actual loading bays which are on the pod entry-exit level. This will make these stations more expensive and less reliable. The stations require a total of at least 49 ft of span – either from sidewalk to median, or from sidewalk to sidewalk (across whole road). These stations provide no protected storage for empty pods.





Pods

The vehicles used by the system are called "pods". Pods are 56 inches tall, 56 inches wide, and 120 inches long. They provide seated positions for 3 people. There is a 2-wide bench seat in the rear with center arm rests to provide 2 comfortable 23 inch wide seats side-by-side. The arm rests can be raised to convert it to a single seat that can accommodate extraordinarily wide passengers. A single executive chair on the left side in the front seats a 3rd passenger. This seat pivots, and can be locked to either face forward or sideways (90 degrees to the right). This makes boarding more convenient, and facilitates group interactions within the vehicle between the front and back positions. The back seat bench also flips up, to increase the space (leg room) between front and back seats. This action provides a 25 inch by 40 inch space into which an electric wheel chair or mobility chair can be directly rolled from the loading doors on the side. This allows the pivoted front seat and the rear bench seats to secure the wheel chair in place for safety during transit, without requiring complicated and heavy ADA restraint equipment.

The pods have sliding doors on the right side which part in the middle to provide a 46 inch wide opening for level boarding. The right side front seating position is de-populated to provide free paths between the side doors and the front and back rows. At the extreme front right floor position are located a collection of bicycle rack posts. This provides for roll-in docking of 2 bicycles. It also provides a secure storage area for bulky carry-on items, like suit cases, grocery carts, e-scooters, baby carriages, etc.

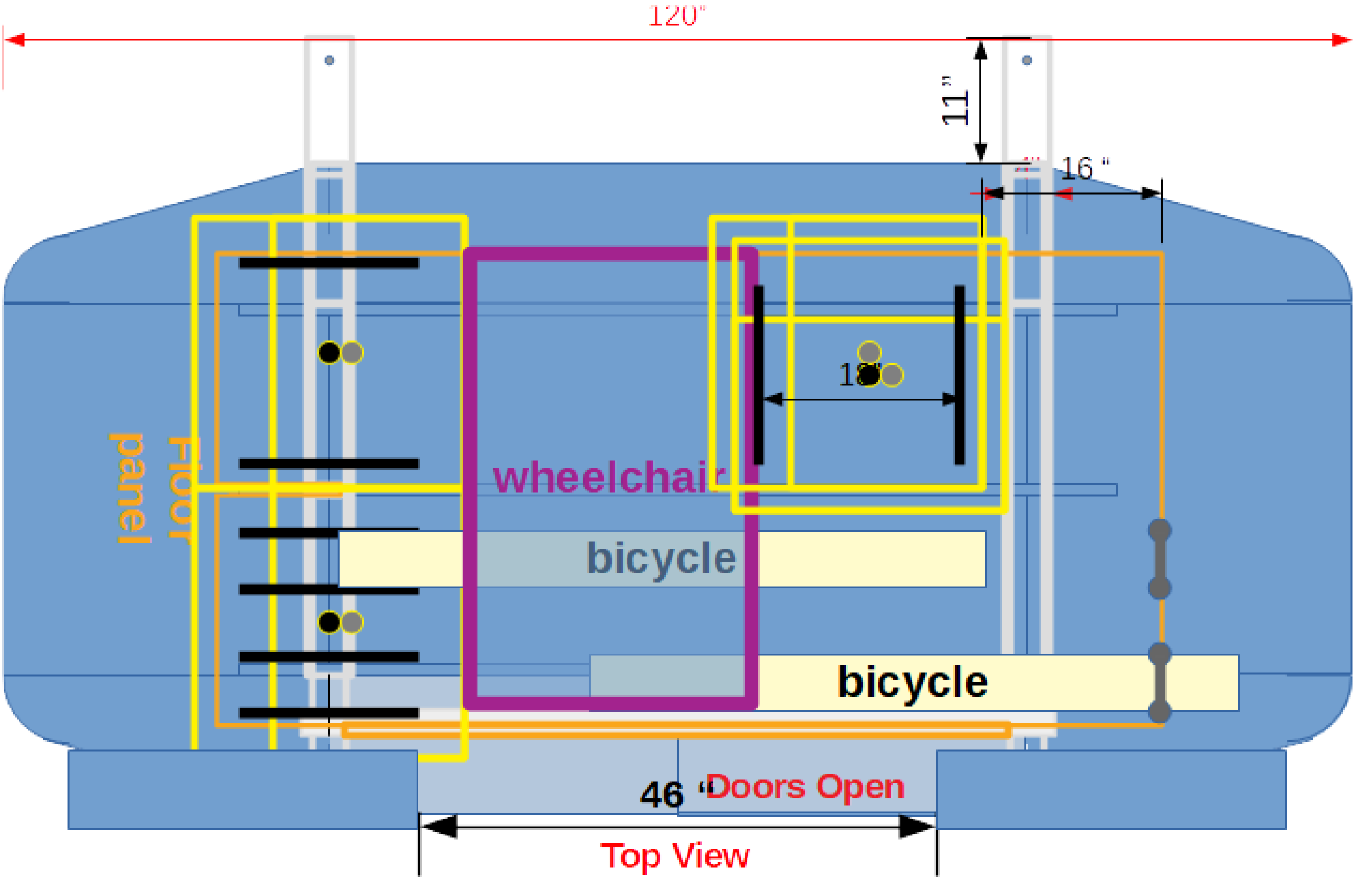
The cabin configuration should comfortably accommodate travelling groups of up to 3 people plus some light cargo, or two people traveling with bicycles or bulky carry-ons. Maximum loading capacity of the pod is 750 lbs. According to CDC body weight statistics, this is sufficient to cover the 95th percentile distribution for groups of 3 adult males with 25 lbs of carry-on; or for groups of a mix of 3 adult men and women with 80 lbs of carry-on; or for groups of 2 adults including 1 electric wheelchair.

A touch screen console is mounted to the vehicle interior side wall proximate to both the front and back rows. This console provides information display, interaction with the control system for station departure or for mid-trip destination change, and for emergency communications if needed.

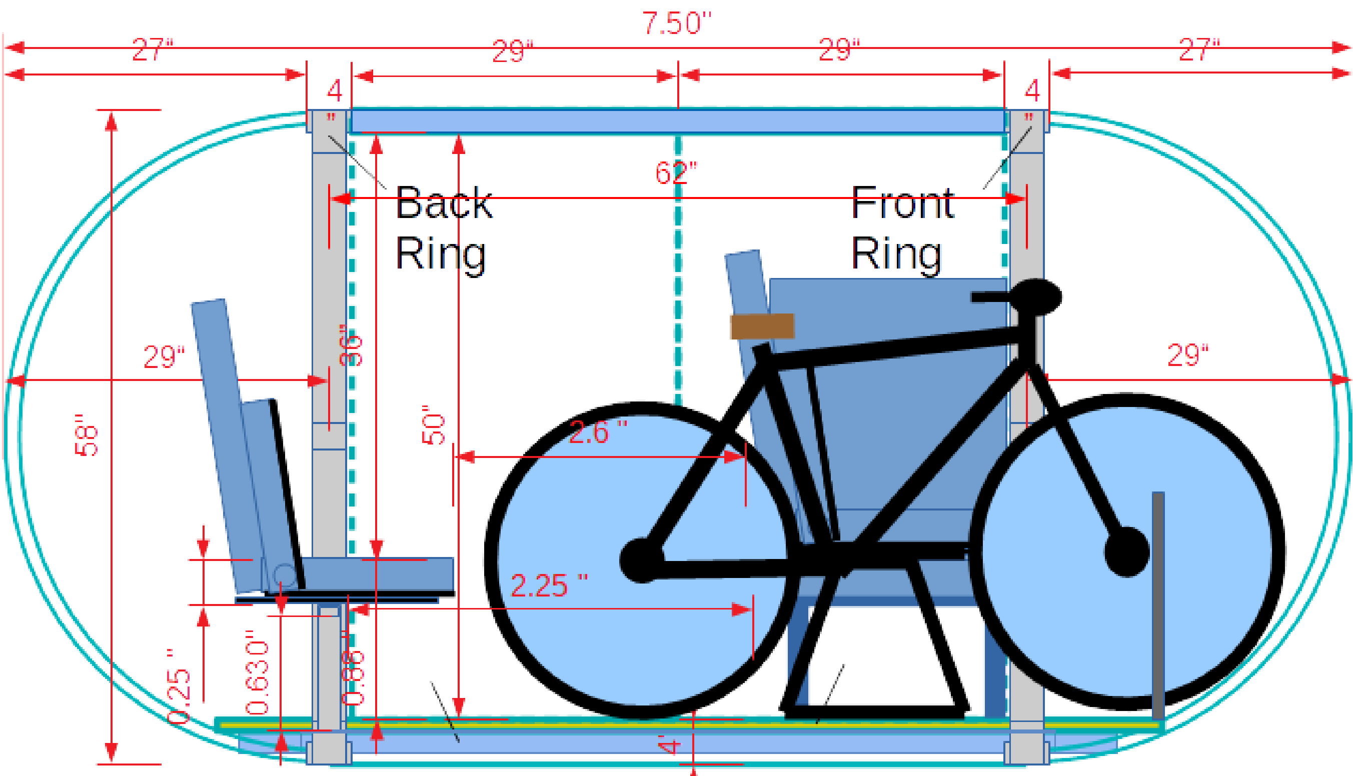
The pod has a small HVAC unit that can provide 2700 BTU/hr (~800 watts) of cooling and 2200 BTU/hr (~630 watts) of heating. The pod shell is designed to be well insulating (like a cooler) – with an R-value of approximately 8. This should maintain a cabin temperature between 60 and 77 degrees Fahrenheit within an external temperature range of 0 to 105 degrees.

The pod is motivated by a 25kw AC motor, and contains a small (1 kwh) battery. An on-board computer controls all pod functions, including communications with central control. Power is received from the guideway. The battery is only used for short power interruptions, as the pod switches into and out of stations for example.

The roller coaster like bogie locks the pod into the guideway. The pods operate only on the guideways. The bogie employs multiple 5 inch polyurethane wheels on aluminum hubs with bearings, providing 6-point reactive forces. This allows the pods to be very lightweight, while still providing a stable, safe, and quiet ride (does not depend upon weight for stability or control). This is key to enabling lightweight – and therefore low cost and visually minimalistic – guideway infrastructure.



Top View



Side Profile

D. Operational Elements

Citytram PRT provides a "constant motion" system – like a conveyor, all vehicles move at the same speed all the time. The system is designed for 45 mph operations (1.33 minutes/mile), but will be introduced initially at 30 mph (2.0 minutes/mile). So transit time for the 3.0 mile trip between SJC and Diridon would be about 6.0 minutes. Departure and arrival times would add to this base trip time.

Dwell time of a pod in a loading bay is dependent upon the riders, but is expected to be about 25 seconds. The full elevator cycle would then vary (depending upon number of bays) around 1 minute. Queueing for departure depends upon network loading, but should be under 2 minutes. So a departure time of 3 minutes and an arrival time of 2 minutes is reasonable to expect. Thus the approximate SJC to Diridon loading bay to loading bay time is 11 minutes (average trip speed 16.3 mph). As a longer trip, DeAnza to Diridon would be faster - 22 minutes for 8.5 miles, and 23.2 mph.

The constant motion system is a "synchronous network", where end-to-end resources are allocated at "circuit set-up". Thus any delays are experienced at entry into the system (departure queue delays). Except in rare circumstances, there are no delays after entry. So typical experience is better than that described above. The best case would occur with an empty pod already waiting at the loading bay, and with no wait at entry to the high-speed main line (circuit setup). In this best case, the departure delay is approximately 40 seconds, including the time accelerating up to line speed. Likewise arrival delay could be as low as 25 seconds for braking, elevator positioning and descent, and alighting, assuming an empty input que and loading bay. Under these conditions SJC to Diridon takes 7.1 minutes (25.4 mph), and DeAnza to Diridon takes 18.1 minutes (28.2 mph). The 45 mph system would be faster still. So the system delivers transit speeds comparable to that experienced by car users, without the risk of congestion delays.

Capacity

The station performance table shown earlier reports the capacity for any one station, both in units of pods per hour, and in people per hour for a couple of average travelling group sizes. The capacity for arrivals is the same as that for departures, and both rates can occur simultaneously.

All travel is point-to-point non-stop – that is from station to station. Any guideway segment (between consecutive stations) will carry all traffic having an upstream origin station and a downstream destination station. All pods travel at the same constant velocity. A minimum of 2 seconds of pod separation (headway) is maintained (88 ft at 30 mph; 132 ft at 45 mph). This limits worst case point loading on any guideway span (between towers). It also provides a theoretical main line capacity of 3600 pods per hour, per direction. Control system resource allocation (circuit setup) for the instantaneous set of trip requests is likely to be capable of exploiting about 80% of that theoretical capacity. So the capacity of a single guideway segment is about 2880 pods/hr, which corresponds to capacity of 3600 pphpd for an average group size of 1.25 people.

Ultimately such links are expected along multiple parallel arterial roads, creating a network. The cross section capacity (cross city) of the network is the sum of these links. System route selection can use multiple paths to distribute the loading.

Empty pods are parked in protected storage within stations. There are also parking sidings built into the guideways. These are distributed throughout the network. In general the system allocation attempts to keep empty pods evenly distributed throughout the network, for minimal response time to new demand which could occur anywhere. As actual demand occurs, empty pods may be moved to re-establish that balance. Advance reservations (discussed later), and patterns learned from operation can be used to set this allocation "balance point". The idea is to set the balance point close enough to the actual demand pattern, and then to have enough locally stored empty pods, so that demand bursts at stations can be responded to with empty pod movement without every making a customer wait for long distance call-up of a pod.

The Experience

It is expected that the majority of users will be regular/repeat users. So the system is optimized around web based accounts. Users can establish accounts that contain balances for automatic fare payments, with on-line usage reporting. These accounts can also be used to schedule/reserve trips – as soon as 24 hours in advance, and as late as 5 minutes in advance. These reservations help the system pre-position enough empty pods where they will be needed. When a user has a reservation, then he/she only needs to checkin upon arrival at a station lobby.

Visitors and users without accounts can purchase a paper ticket at the station lobby. The ticketing process (and account setup) include one uncommon step. The rider must provide an estimate of his/her weight. A SMART phone app will be available. This can be used as an alternative to paper tickets, even for users without web accounts.

Upon arrival at a station the rider will enter the lobby, and approach a kiosk. Ticketing and/or checking is performed, using either the touchscreen console on the kiosk, or using NFC communications from the SMART phone app. The checkin process directs the rider's group to a loading bay by number. The rider group proceeds to that bay and waits at the entrance gate, touching a button to announce readiness to board. When an empty pod is in the loading bay the entrance gate opens, and the group boards.

The floor of the loading area has pressure sensors, as does the loading bay elevator. The system will see the floor weight and pod weight both go from 0 to positive, and end with no load on the floor and the predicted (from passenger information) load on the pod. This prevents "turn-style jumping" (where free-loaders attempt to piggyback on legitimate trips).

Once seated the riders push a button in the pod to indicate "ready for travel". The pod is equipped with seat belt sensors and occupancy sensors on each seat. If the right number of seats are occupied, and each occupied seat has an engaged seat belt, and the total laden weight of the pod is within the allowed spec, then the system closes the pod door. A short wait (10 seconds) may be required to synchronize with other loading bays in the elevator cycle. The elevator will then lift the pod to the entry/exit level, and the pod will roll forward in line with pods from the other bays into the departure queue. As pods in front depart, the pods rolls forward. Shortly the pod reached the departure position, and then accelerates through the exit lane, and switches into an empty slot in the main line. In order to minimize the motor requirements on the pod, the exit lane has a built in-launcher (acceleration assist).

The vehicle moves at constant velocity down the guideway, passing by all intermediate stations. Upon approach to the destination station the system positions the pod steering wheel so that it takes the exit path at the station switch. The vehicle decelerates through the off-line braking lane, and then proceeds at low speed to the station arrival queue. The pod advances through the queue, and then ultimately rolls into a system designated the elevator. The elevator descends into the loading bay and the door opens. The riding group departs the pod onto the boarding floor near the exit gate.

The vehicle has an interior facing camera. The front and back seats each have 2 positions, so there are 4 valid configurations of the interior. Images of those 4 configurations are stored in the on-board computer. Once the riders have departed the pod, the pod takes another interior picture and compares it to the stored reference images. If none are matched, or if the elevator weight sensor indicates other than the empty pod weight, then the exit gate does not open. Instead a console indicates the trouble condition. Perhaps the group left cargo on board (or perhaps some vandalism occurred). A central control operator is notified, in case the riding group is not able to resolve the issue on their own. In the worst case, security personnel are dispatched to the station. Riders are held responsible for any non-routine damage to pods.

Once the exit conditions are satisfied, the exit gate is opened and the riders exit the loading bay. When the system detects no load on the boarding floor, it closes the exit door, and the loading bay is ready for a departing group.

Station management attempts to maintain half the bays empty, and therefore ready for an arriving pod, and the other half occupied with empty pods, and therefore ready for a departing group. The system also has awareness of scheduled arrivals of pods in transit, which will need empty bays. So the station may move empty pods between the bays and the protected pod storage internal to the station.

In the rare cases when station management is not able to satisfy departure demand, then checkin may direct the rider group to the lobby seating, rather than to a numbered bay. Displays are available in the lobby areas, and will alert the group when their departure bay is determined.

[redacted]

[redacted]

[redacted]

F. Concept Requirements

The concept is to use the space above existing roadways. The support structures, and their foundations will need to be placed along the edges of those roadways (including medians). Unfortunately many jurisdictions also use the roadways for underground utilities – water, sewer, buried power. If such services run parallel to the roadway (rather than across it) for substantial distance, then it may make locating the PRT foundations too difficult.

The infrastructure is designed with construction in mind. Pre-manufactured pieces are transported to the site and erected. It is estimated that a single crew can erect about 2 miles of guideway per month, while a separate crew constructs the stations. So the SJ alignment could be constructed in approximately 6 months. This assumes the alignment has been prepared – utility relocations – and permitting does not delay progress.

It is expected the SPE will be launched and staffed during construction. But agency involved safety certification of the site, with the SPE O&M team, may take a year.

Because standardized sections are used to construct the guideway, and because joining of the section uses structural bolts, future reconfiguration of the alignment is relatively easy. A main line section is removed from the alignment, and replaced with a switching section (with the exit path disabled). This can be done in just a few hours. Additional guideway can then be constructed connecting to the exit path of the switch.

The guideways require very little in the way of maintenance. Regular inspections for corrosion or degradation of joining bolts is automated (monitored videos from exterior cameras on maintenance pods). Sensors and communications are self-monitoring.

Security and cleaning staffs perform frequent regular inspections of all pods. They have relatively few moving parts.

G. Costs

The construction costs are estimated in detail in section H. The unit costs shown there are our best efforts values. But there are specifics for any alignment that result in variation both in pre-construction and in material costs. Pre-construction costs will vary for tree removal, and for utility location and/or re-location. Foundation costs can vary significantly based upon geotechnical test findings. Detailed alignment choices can impact tower spacing, and therefore impact design estimate accuracy.

H. Deployment Business Plan

A public-private-partnership (P3) is the recommended structure for this service. The public shall provide the right-of-way and permitting, and perhaps milestone and/or availability payments. A special purpose entity (SPE) - independent business - will create the infrastructure asset and operate the service. A financial model for this special purpose entity shows both that it is a viable profit making business, and that using a mileage based fare is best. Since VTA does not use a mileage based fare, integrating with VTA's fare system may be problematic. That is likely an item that mighty justify availability payments, which would otherwise not likely be needed nor justifiable.

The SPE would 1) secure infrastructure financing; 2) provide performance bonding; 3) contract for construction services; 4) contract for engineering services for certification of the system; 5) hire and train the operations team; and 6) operate the service as a for profit business. Citytram would participate as the PRT technology supplier; would contribute resources to the system design and negotiation phase with the agencies involved (to defines what the SPE will deliver); would recruit the SPE founder(s); and might well contribute seed funding needed to launch the SPE (in return for equity in the SPE). In addition to being the customer for the SPE, the city might consider 1) participating as a financier for the infrastructure; 2) providing seed funding for equity in the SPE (including board positions); 3) recruiting the founder(s) to run the entity. If any of this is done, care should be taken to NOT involve federal funds (even if provided through the state government). Involving such funds could inadvertently restrict SPE operations – force buy America; force unionized labor; limit/complicate hiring practices, etc.

Citytram's electronic submission will include spreadsheet models for the SPE. Each of these is a multi-tab workbook. The key findings are summarized here. The second largest single operating expense is that of staff salaries. Based upon expected ridership and site and equipment specs, it appears a staff of 38 people is needed. This comes with an expense of $1.6M/yr.

Staffing Model - Operation SPE

SJC-Diridon-Stevens Creek

dept	symbol	job title		cost rate $/hr	number employees	total cost $/yr	loaded cost $/person-yr	planned work hrs/yr
		Total Company		**$228.46**	**37.9**	**$1,663,179**		**7280**
Operations								
	O1	Operations Superviser		$25.19	2	$95,930	$47,964.80	1904
	O2	IT engineer		$31.49	2	$119,912	$59,956.00	1904
	O3	customer support agent	c	$18.89	2	$71,947	$35,973.60	1904
	O4	rider assistence agent	c	$18.89	6.9	$248,218	$35,973.60	1904
	O5	operations technician		$21.41	2	$81,540	$40,770.08	1904
	O6	security agent	c	$17.63	6	$201,452	$33,575.36	1904
Maintenance								
	M1	Maintenance Supervisor		$30.23	1	$57,558	$57,557.76	1904
	M2	vehicle cleaning technician	c	$18.89	3	$107,921	$35,973.60	1904
	M3	station cleaning technician	c	$18.89	6	$215,842	$35,973.60	1904
	M4	vehicle maintenance technician		$39.05	1	$74,345	$74,345.44	1904
	M5	infrastructure maintenance technician		$35.27	3	$201,452	$67,150.72	1904
Administration								
	A1	chief executive		$35.27	1	$67,151	$67,150.72	1904
	A2	payroll & accounting manager	c	$35.27	1	$67,151	$67,150.72	1904
	A3	Human Resources manager	c	$27.71	1	$52,761	$52,761.28	1904

The largest SPE expense is debt service to retire the infrastructure construction loan. This is estimated as a $60M project. The construction estimate is documented here.

PRT Construction Financial Model

San Jose - Steven Creek & SJC Corridor

	Project Phase	Total	SJC connect 1	Stevens Creek 2	North San Jose 3	4
Total		$59.82	$22.94	$36.88		
Guideway		$38.59	$12.55	$26.05		
Stations		$10.29	$4.31	$5.98		
Ops Center		$0.40	$0.40	$0.00		
Maintenance & Storage Depot		$3.28	$3.28	$0.00		
Vehicles		$7.27	$2.42	$4.86		

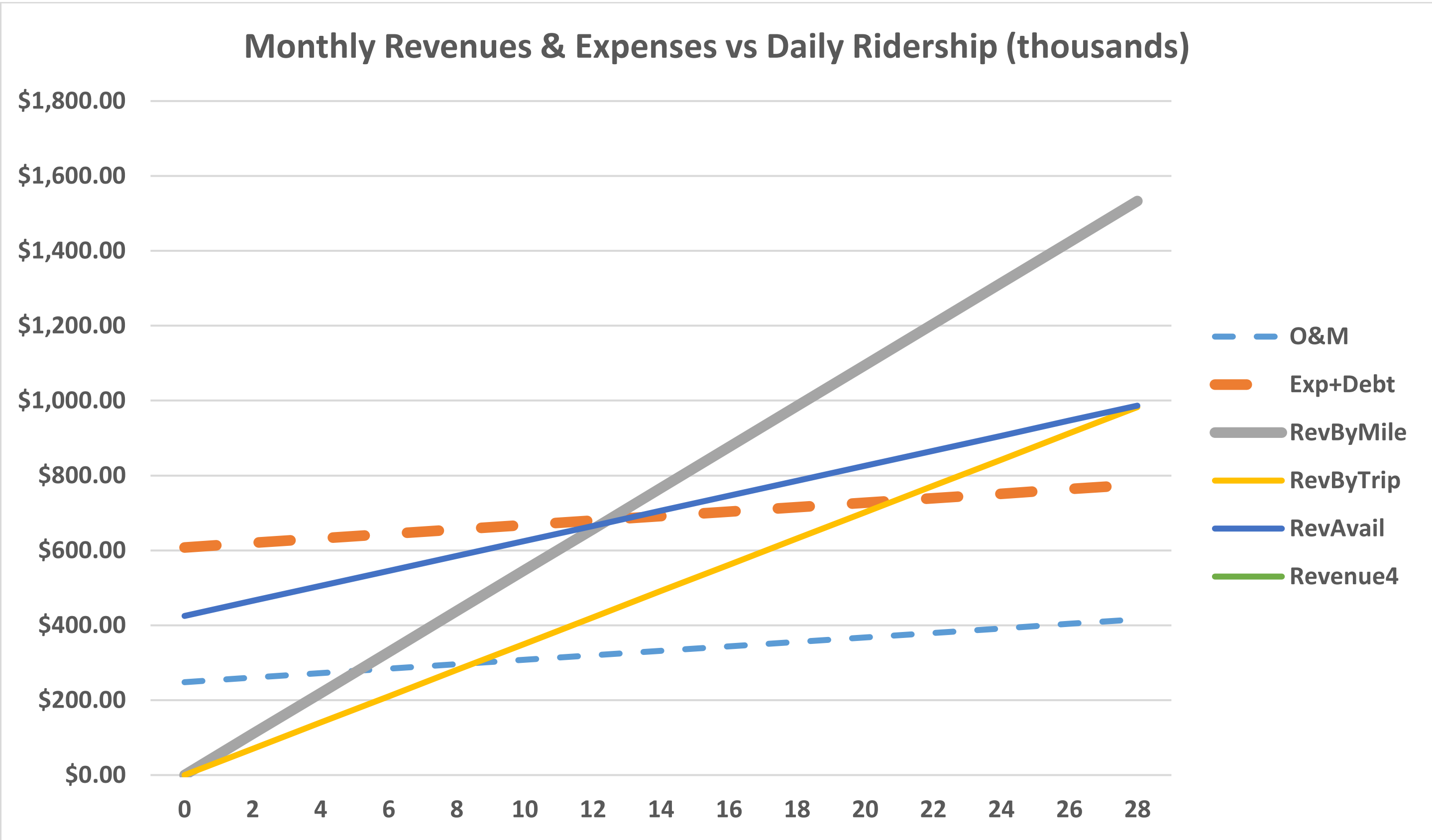
	Project Phase	Total	1	2	3	4	Unit Cost ($M)
Guideway							
1-way length	(miles)	2.00	1.00	1.00			$3.00
2-way length	(miles)	10.50	3.00	7.5			$3.00
total guideway length	(miles)	12.50	4.00	8.50			
run track length	(miles)	23.00	7.00	16.00			
parking track length	(miles)	0.45	0.23	0.23			$2.40
total track length	(miles)	23.45	7.23	16.23			
constructed cost	($M)	$38.59	$12.55	$26.05			
Stations							
number		29	12	17			$0.30
Average loading bays per station	bays/station		6	4			
extra guideway to access station	miles		0.1	0.1			$3.00
constructed cost	($M)		$3.90	$5.40			
furnishings	($M)		$0.14	$0.20			$0.012
equipment	($M)		$0.26	$0.37			$0.022
total cost	($M)		$4.31	$5.98			
Ops Center							
building area	(ft^2)		2,100				
building cost	($K)		$31.50				$15.00
equipment cost	($K)		$200.00				
land cost	($K)		$165.00				
Total Cost	($M)		$0.40	$0.00			
Maintenance & Storage Depot							
Safe Pod Storage							
pod storage width	(ft)		6.0				
pod storage area	(ft^2)		72.00				
pod storage margin	(%)		10%				
pod storage levels			5				
pod storage floor area	(ft^2)		4,607.1				
Pod Cleaning							
auto-washer area multiple			4.00				
interior-cleaning area multiple			3.20				
number auto-washer bays			3				
number interior-cleaning bays			5				
pod cleaning floor area	(ft^2)		2,016.00				
equipment	($K)						
Maintenance Bays							
maintenance bay area multiple			6.00				
number auto-washer bays			5				
maintenace floor area	(ft^2)		2,160.00				
equipment	($K)						

Parts Storage	(ft^2)		864.00			
Office Area	(ft^2)		720.00			
Lunch Room Area	(ft^2)		600.00			
Locker Room Area	(ft^2)		600.00			
Hallways	(ft^2)		600.00			
Total Floor Area	(ft^2)		12,167.06			
area margin	(%)		20%			
building cost	($K)		$175.21			$12.00
equipment cost	($K)		$1,100.00			
land cost	($M)		$2.00			
Total Cost	($M)		$3.28	$0.00		
Vehicles						
number		291	97	194		
cost	($M)	$7.27	$2.42	$4.86		$25,000
PRT Site Provisioning Calculation						
How many pods do I need ?						
It depends upon demand (ridership) and service (latency) guarantees						
Service Parameters						
avg route speed	mph	30				
Service guarantee – max wait time	minutes	5				
pod storage length	ft	12				
bays used for parking	%	50%				
spare vehicles	%	5%				
Demand: Originations (rides,trips)						
ridership planned	rides/day		10,000	7,000		
avg occupancy	pass/ride		1.3	1.2		
	trips/day		7,692	5,833		
service day	hours/day		17	20		
avg trip origination rate	trips/hour		452	292		
	trips/min		8	5		
dynamicity (peak/average)	ratio		1.35	2.00	#1	
peak origination rate	trips/min		10	10		
Saturation Calculations (vehicles to guarantee service rate)						
(max) trip length	miles		3.5	6		
(max) round trip	miles		7.0	12.0		
(max) Round trip time	hours		0.23	0.40		
	minutes		14	24		
Service guarantee – max wait time	minutes		5	5		
max burst duration to cover	minutes		9	19	#2	
fleet size to maintain peak rate during this p	pods		92	185		
fleet size	pods		97	194		
storage distribution	pods/mile		13.14	11.56		
Parking Calculations						
station density	stations/mile		1.71	1.06		
Average pod storage in each station	pods/station		15	9		
pod storage in all stations	pods		180	153		
min pod storage in guideway	pods		-88	32		
provided pod storage in guideway	pods		100	100		
siding length (for guideway parking)	ft		1200	1200		
parking density	ft / mile		171.4	75.0		
portion of guideway with siding	%		3.25%	1.42%		

#1 demand varies above & below average during the day
#2 (before empty pods return from round trip)

The third largest SPE expense is contribution to a reserve fund for replacement equipment. The good news is this means a loan will not be needed in the future to fund this replacement. The one time loan establishes an asset that is self-sustaining in perpetuity (well at least for the life of the asset – which should be longer than the life of the loan). So once the loan is retired, profitability soars!

These expense models (and others) are rolled up. Several fare models were examined, as a function of daily ridership. The result is the following graph.



Pricing Models

		1	2	3	4
availability	$K/mnth	$0.00	$0.00	$425.00	
fare	$/trip	$0.00	$1.75	$1.00	
fare	$/mile	$0.50	$0.00	$0.00	
		RevByMile	**RevByTrip**	**RevAvail**	**Revenue4**

The corridor ridership is estimated to be 17,000/day. RevenueByTrip (per trip fares) works poorly. Public transit fares on a per mile basis are below cost. This is a competitive necessity since public transit service speeds are so low. It may also be a social goal (subsidy for the poor). But it does not work as a business. Revenue from Availability payments can be made to work. But this is just a negotiation for that subsidy, and it has a reverse incentive. The SPE does best by negotiating a high payment, and then discouraging ridership to lower variable costs (thus maximizing profit). The best model is RevenueByMile. The service is speed competitive with car use. So a per mile price ($0.50/mile) below that of the per mile use cost for cars ($0.73/mile) should be attractive to choice riders (similar value at a lower price). This rate is profitable at about 12,000 riders/day (covering both operations and debt service).

Channeling this profit into future system expansions should provide excellent leverage. The more places the system can reach system, the more attractive it becomes to choice riders.

I. Impacts

As with any elevated infrastructure, there is some complaint from the public. Tree removal may be required, and some will be quite unhappy with that. Some will consider the new infrastructure un-attractive and complain. Others having second or third story properties near the alignment will consider it intrusive (privacy concerns).

Good planning and community outreach are the best mitigations. Avoid trees and residential windows when possible; add shielding landscaping (eg. trellis and vines) to protect privacy and hide “unattractiveness”; and finally tell the residents what is coming in advance, and enlist them in suggesting improvements to minimize their concerns.